SLATE

BY OLIVER BOWLES

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INTRODUCTION

The term "slate" is applied to fine-grained rock that has a more or less perfect natural cleavage, permitting it to be split readily into thin, smooth sheets. Originally slate was used almost exclusively for roofing, but later many other uses were developed for it.

The discussion herein is confined primarily to dimension slate. Slate is used for making granules and flour, but their manufacture is a segment of the crushed-stone industry, which involves processes and equipment entirely different from those used in dimension-slate production. Only incidental reference to granules and flour will appear in this report.

ORIGIN AND CHARACTER

Excepting certain rare slates of igneous origin formed from volcanic ash or igneous dikes, slates have originated from sedimentary deposits consisting largely of clay. Such materials were carried by streams and deposited in bodies of water in successive horizontal beds. Other materials such as calcium carbonate, sand, or gravel may have been deposited over the clays, and the pressure of the superimposed materials may have gradually consolidated them into bedded deposits of shale such as are found in many places. Shale is a laminated rock consisting essentially of clay, but it does not have the splitting properties of slate.

Many shales, however, have been subjected to intense metamorphism. Mountain-building forces ever at work in the earth's crust may crumple, squeeze, and fold the shales. At the same time accompanying high pressures and temperatures may change the original clays into new minerals, such as mica, quartz, or chlorite. Both mica and chlorite consist of minute tabular sheets or flakes. The intense pressure and movement tend to orient these flakes in parallel positions normal to the direction of pressure. The parallelism of the mineral grains results in the tendency to split with ease in one direction, which has been termed "slaty cleavage" and which is the outstanding characteristic of slate. The original bedding of the rock is often folded and contorted, and only occasionally is the slaty cleavage parallel with it; in fact, it commonly cuts across it at sharp angles.

COMPOSITION

Mineralogical Composition

The most abundant mineral in slate is white mica (sericite), a hydrous silicate of potash and aluminum. It is present in very small flakes recognizable only with a microscope. Small grains of quartz (silicon dioxide) are also abundant and are regularly distributed among the mica flakes. The micalike mineral, chlorite, is usually present in condiserable quantities. Chlorites are of several kinds, the more common being hydrous silicates of aluminum and iron or magnesium. Small quantities of clay are usually present. Other minor constituents are rutile,

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hematite, pyrite, carbonaceous matter, feldspar, zircon, tourmaline, calcite, dolomite, and siderite. The general range of the chief constituents is about as follows: Sericite, 38 to 40; quartz, 31 to 45; chlorite, 6 to 18; hematite, 3 to 6; and rutile, 1 to 1-1/2 percent.

Chemical Composition

Results of many analyses indicate that clays, shales, and slates differ little in chemical composition. The changes that take place during metamorphism are confined largely to rearrangement of the elements into new minerals with accompanying changes in physical properties such as hardness and cleavage. The general average percent of the principal constituents is about as follows: SiO_2, 55 to 67; Al_2O_3, 11 to 19; FeO, 1 to 7; Fe_2O_3, 1 to 4; K_2O, 3 to 6; MgO, 2 to 5; CaO, 0.5 to 4; and H_2O, 3 to 4.

SLATE STRUCTURES

Slaty cleavage is the structure that, above all others, differentiates slate from other rocks and gives it economic value. Some Pennsylvania slates can be split as thin as one-thirty-second of an inch, but such sheets are too thin for practical use. In the manufacture of blackboard slates, uniform, smooth slabs 4 by 6 feet or larger may be readily split to a thickness of 3/8 inch.

Grain is a second direction of splitting much less pronounced than slaty cleavage and usually at right angles to it. The grain direction is utilized to obtain uniform fractures in separating large blocks at the quarry face, and in reducing them to convenient sizes. In the manufacture of roofing slates the grain should always be parallel with the long axis so that, in case of slate breakage, the fracture will tend to parallel the dip of the roof and so minimize leakage.

Joints are structures that are of great importance in the quarrying process. They may be defined as more or less parallel systems of cracks or fractures in rocks. In slate deposits joints are classified according to their directions. Strike joints are those that parallel the strike of the beds; dip joints parallel the direction of dip, and those that intersect both strike and dip are termed "diagonal joints."

"Ribbons" are structures that appear in certain slates, notably in Pennsylvania. The term is applied to bands that cross the blocks of slate at various angles. They consist of minor beds differing in composition from the main body of the slate. In some deposits the ribbons are rich in carbonaceous material and so are darker in color than the slate between them. They weather more rapidly than the clear slate, hence they are not adapted for uses that expose them to the weather. In some slates the ribbons are not objectionable. Open joints that parallel the bedding are sometimes termed "loose ribbons."

Other structures that appear at times in slate deposits are veins of quartz or calcite, igneous dikes, and nodules of quartz or pyrite.

PHYSICAL PROPERTIES

Slate is of medium hardness, low porosity, and high strength; is very fine grained; and consists essentially of minerals that are stable and resistant to weathering. Slate commonly weights 170 to 180 pounds per cubic foot. The more common colors are gray, bluish gray, blue black, black, and various shades of green. Variegated colors, purples, and reds are less common.

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DURABILITY

Slates consist essentially of quartz and stable silicate minerals that are highly resistant to weathering, accordingly high-grade mica slate is a remarkably durable building material. Slate roofs that have stood for centuries in the Old World are still in good condition. Certain impurities, however, may detract from its durability. Slates containing clay are porous, and water absorption hastens disintegration. Carbonates are particularly detrimental in industrial areas. Acids carried in the atmosphere react with calcium carbonate to form gypsum, which, by expansion, disrupts the slate structure.

USES

Roofing

The original and virtually the only use for slate for many years was for roofing. Because of its durability, attractiveness, and nonflammability slate is a superior material for such use. The essentials of slate for roofing are straight, uniform, and smooth cleavage, an attractive color that does not fade or fades uniformly, and absence of mineral constituents that react with relative ease under the influence of atmospheric agencies.

In the United States slates are sold by the "square" - enough slate to cover 100 square feet with a 3-inch head lap. In France and England the unit is a "mille," 1,200 slates of any given size and 60 additional to cover loss by breakage. Slates range in size from 7 by 9 to 16 by 24 inches, and the number of slates required for a square ranges from 85 to 686 according to the size. Ordinary slates range from 1/8 to 1/4 inch thick; 3/16 is a well-established thickness. The weight of a square of average roofing slate is 650 pounds.

Mill Stock

Blackboards and School Slates

Slate suitable for blackboards must be soft, uniform, and fine-grained. Such slate occurs in what is known as the soft-vein region of Lehigh and Northampton Counties, Pa. It is the northern slate belt, which includes the region in and about Bangor, East Bangor, Pen Argyl, Danielsville, Slatington, and Slatedale. This comparatively small area, not over 22 miles long, comprises the most widely used blackboard slate deposits in the world. Because of their smoothness, uniformity, permanence, and attractiveness, slate blackboards are generally regarded as superior to all other types of blackboards now in use.

School slates were once common in America, but their use has greatly declined. As they are small, their manufacture permits utilization of the smaller pieces many of which would otherwise be wasted. School slate is similar to blackboard slate, and production is largely confined to the same area. Because of increasing imports, particularly from Italy, Portugal and Germany, domestic output has declined greatly during recent years.

Structural Slate

The term "structural" as used in the slate industry relates to products used chiefly for interior and sanitary purposes. The chief structural-slate products are mantels, floor tiles, steps, risers, flagging, skirting board, window sills,

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lavatory slabs, billiard and other table tops, laboratory sinks and hoods, wainscoting, hearths, well caps, vats, sinks, laundry tubs, vaults, refrigerator shelves, flour bins, and dough troughs. A soft, even-grained slate, preferably not highly fissile, is required for such purposes.

Electrical Slate

Slate is used widely where low electric conductivity and mechanical strength are required. Because of its toughness, easy workability, low cost, and ease of matching when switchboards are enlarged, it is a preferred material. Electrical slate should be of such quality that it can be cut and drilled without scaling. It must be free of magnetite and other low-resistance minerals.

Flagstones and Related Products

Irregular slabs of slate are used extensively for flagging on terraces, steps, walkways, porches, and promenades, or as stepping stones. Slates from different localities may be employed to give a varied pattern.

Uses of Waste Slate

Waste slate may be pulverized into flour, which finds many uses as a filler in paint, linoleum, roofing mastic, road asphalt, and other products. It may also be crushed into granules used as a surfacing material on composition roofing.

HISTORY

Slate was used for roofing in England as early as the 8th century and in Wales and France during the 12th century. The oldest slate quarry in the United States was opened in the Peach Bottom district near Delta, Pa., in 1734. Slate quarrying began in Virginia about 1787, in Georgia in 1850, and in the Lehigh district of Pennsylvania at a later date. Growth of the industry in the United States has been slow because quarrying is relatively expensive, the proportion of waste is high, and because hand methods are widely used in fabricating slate products. Because of the relatively high prices that ensue slate has failed to maintain a favorable position in the competitive field.

Table 1 is a historic record of slate production by principal uses from 1887 to 1953.

DISTRIBUTION OF DEPOSITS

Deposits of the United States

General Distribution

The major slate-producing districts of the United States are the Monson district, Maine; the New York-Vermont district, including Washington County, N. Y., and Rutland County, Vt.; the Lehigh district, including Lehigh and Northampton Counties, Pa., and Sussex County, N. J.; the Peach Bottom district including Lancaster and York Counties, Pa., and Harford County, Md.; and the Buckingham County and Albemarle County district of Virginia. These districts produce one or more of the principal slate products, namely roofing slate, mill stock, flagging, roofing granules, or flour. Granules, flour or flagging are produced at times in Arkansas, California, Georgia, Michigan, Tennessee, and Utah.

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TABLE 1. - Quantity and value of roofing slate and millstock produced in the United States, 1887-1953

Year	Roofing slate			Millstock			Other uses, value	Total value
	Number of squares	Value	Average price per square	Quantity, square feet	Value	Average price per square foot		
1887	573,439	$1,720,317	$3.00	-	-	-	-	$1,720,317
1888	662,400	2,053,440	3.10	-	-	-	-	2,053,440
1889	835,625	2,797,904	3.35	-	$684,609	-	-	3,482,513
1891	893,312	3,125,410	3.50	-	700,336	-	-	3,825,746
1892	953,000	3,396,625	3.56	-	720,500	-	-	4,117,125
1893	621,939	2,209,049	3.55	-	314,124	-	-	2,523,173
1894	738,222	2,301,138	3.12	-	489,186	-	-	2,790,324
1895	729,927	2,351,509	3.22	-	347,191	-	-	2,698,700
1896	673,304	2,263,748	3.36	-	482,457	-	-	2,746,205
1897	1,001,448	3,097,452	3.09	-	427,162	-	-	3,524,614
1898	916,239	3,129,390	3.42	-	594,150	-	-	3,723,540
1899	1,100,513	3,454,817	3.14	-	507,916	-	-	3,962,733
1900	1,194,048	3,596,182	3.01	-	644,284	-	-	4,240,466
1901	1,304,379	4,114,410	3.15	-	673,115	-	-	4,787,525
1902	1,435,168	4,950,428	3.45	-	745,623	-	-	5,696,051
1903	1,378,194	5,345,078	3.88	-	911,807	-	-	6,256,885
1904	1,233,757	4,669,289	3.78	-	947,906	-	-	5,617,195
1905	1,241,227	4,574,550	3.69	-	921,657	-	-	5,496,207
1906	1,214,742	4,448,786	3.66	-	1,219,560	-	-	5,668,346
1907	1,277,554	4,817,769	3.77	5,979,624	943,409	$0.157	$258,042	6,019,220
1908	1,333,171	5,186,167	3.89	4,793,812	793,304	.165	337,346	6,316,817
1909	1,133,713	4,394,597	3.87	5,112,894	876,089	.171	170,732	5,441,418
1910	1,260,621	4,844,664	3.84	5,181,498	999,098	.192	392,997	6,236,759
1911	1,124,677	4,348,571	3.87	5,744,577	1,027,605	.178	351,843	5,728,019
1912	1,197,288	4,636,185	3.87	5,765,273	1,013,220	.176	393,913	6,043,318
1913	1,113,944	4,461,062	4.00	6,312,011	1,233,838	.195	480,576	6,175,476
1914	1,019,553	4,160,832	4.08	5,361,925	977,930	.182	568,025	5,706,787
1915	967,880	3,746,334	3.87	4,576,112	819,672	.179	392,909	4,958,915
1916	835,873	3,408,934	4.08	5,782,842	1,177,260	.20	752,643	5,338,837
1917	703,667	3,411,740	4.85	5,478,151	1,277,249	.23	1,060,977	5,749,966
1918	379,817	2,219,131	5.84	4,841,133	1,498,164	.31	1,123,825	4,841,120
1919	454,337	3,085,957	6.79	7,466,000	1,782,793	.24	1,161,898	6,030,648
1920	396,230	3,524,658	8.90	9,910,000	3,147,281	.32	2,054,503	8,726,442
1921	348,085	3,197,745	9.19	8,970,000	2,719,723	.30	1,404,538	7,322,006
1922	479,243	4,069,761	8.49	9,276,800	2,899,195	.31	2,207,828	9,176,784
1923	507,587	4,582,535	9.03	11,109,480	4,159,644	.37	3,334,445	12,076,624
1924	469,393	4,626,614	9.86	10,009,180	3,922,366	.39	3,227,036	11,776,016
1925	494,530	5,084,945	10.28	11,077,860	4,231,477	.38	3,258,904	12,575,326
1926	465,900	5,079,087	10.90	10,278,130	4,191,185	.41	3,082,495	12,352,767
1927	468,560	4,949,940	10.56	9,287,680	3,519,386	.38	2,911,410	11,380,736
1928	483,280	5,411,332	11.20	9,220,170	3,408,304	.37	2,652,655	11,472,291
1929	462,120	4,920,766	10.65	9,936,480	3,702,145	.37	2,622,267	11,245,178
1930	340,140	3,359,939	9.88	7,917,220	2,755,530	.35	1,796,149	7,911,618
1931	277,700	2,364,861	8.52	5,794,380	1,754,054	.30	1,379,421	5,498,336
1932	144,410	1,072,255	7.43	2,840,020	810,443	.29	1,221,602	3,104,300
1933	153,170	967,834	6.32	2,089,650	519,078	.25	1,209,273	2,696,185
1934	137,010	1,033,164	7.54	2,113,620	581,959	.28	1,092,805	2,707,928
1935	221,630	1,456,041	6.57	2,994,470	849,796	.28	1,343,678	3,649,515
1936	336,130	2,607,402	7.12	4,108,450	1,175,668	.29	1,702,138	5,485,208
1937	365,800	2,728,109	7.46	4,194,160	1,225,645	.29	1,651,568	5,605,322
1938	322,040	2,247,910	6.98	3,575,220	853,602	.24	2,553,801	5,655,313
1939	399,320	2,868,961	7.18	4,044,530	1,168,671	.29	2,644,582	6,682,214
1940	347,130	2,436,123	7.02	3,120,120	935,810	.30	2,366,336	5,738,269
1941	378,980	3,180,766	8.39	3,245,270	1,076,814	.33	3,258,054	7,515,634
1942	192,070	1,704,053	8.87	3,213,410	1,112,426	.35	3,543,744	6,360,223
1943	96,220	841,750	8.75	2,644,140	938,368	.35	3,090,119	4,870,237
1944	89,090	802,179	9.00	2,041,210	715,689	.35	3,486,327	5,004,195
1945	101,300	976,122	9.64	2,107,780	742,345	.35	3,940,446	5,658,913
1946	146,790	1,982,928	13.51	2,371,820	1,032,584	.44	5,828,594	8,844,106
1947	170,590	3,094,780	18.14	2,549,080	1,444,835	.57	7,145,939	11,685,554
1948	218,650	4,566,056	20.88	2,541,250	1,600,019	.63	6,714,854	12,880,929
1949	181,490	3,759,564	20.71	2,741,040	1,727,649	.63	6,677,063	12,164,276
1950	197,570	4,098,842	20.75	3,180,600	2,130,430	.67	8,818,209	15,947,481
1951	205,120	4,357,412	21.24	3,168,540	2,127,387	.67	8,049,528	14,534,327
1952	145,640	3,967,513	21.06	2,725,660	2,049,895	.75	7,589,243	12,706,651
1953	142,292	3,005,649	21.12	2,940,527	2,220,504	.76	7,412,312	12,638,465

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Maine

Slate occurs in Maine in a belt 15 to 20 miles wide lying at about the center of the State in southern Piscataquis County. The strike is in general northeast, and the dip is very steep, ranging from 80° to vertical. Production is confined almost exclusively to the vicinity of Monson. The commercial beds consist of fine-grained, dense, uniform, blue-black slate. The slaty cleavage is vertical and therefore is nearby parallel with the bedding. Underground mining is conducted chiefly on one 9-foot, nearly vertical bed and several adjacent smaller beds. Monson slate is especially adaptable for making switchboards, panels, and other electrical insulators. Production has been recorded at times from nearby North Blanchard and Brownsville.

New York-Vermont

An important slate district extends from Rutland County, west central Vermont, into Washington County, N. Y. The slates are of two geologic ages; those of Ordovician age including red, bright green, and black slates and those of Cambrian age including green, purple, and variegated slates. In general the slaty cleavage dips east 30° to 50° and either parallels the beds or crosses them at a low angle. This area is the source of the so-called colored slates. One type is the sea green. When first quarried it is gray or slightly greenish-gray and after a few years of exposure, its color changes to a buff or brownish gray. This color aging is preferred by some architects and builders. Another type is the unfading green. This slate maintains its greenish-gray color indefinitely. The so-called purple slate is a purplish brown, the purple color being attributed to a mixture of the red of hematite with the bluish green of chlorite. A variegated type is greenish brown with irregular purple patches giving a mottled effect. Red slates associated with bright-green varieties of Ordovician age occur near Granville, Washington County, N. Y. The red color is due to abundant hematite. They are used at times for roofing.

Aside from granules and flour, the products of the Washington County, N. Y., quarries centered near Granville and Middle Granville are roofing slate and flagging. In the southern slate district of Vermont, which extends from Poultney to West Pawlet, the chief product is roofing slate. In the northern district of Vermont near Fair Haven and Hydeville both roofing and mill stock are produced. Certain purple and green slates are used for making products such as floor tile, vats, mantles, baseboards, sills, steps, and to a small extent billiard-table tops and electrical panels.

Heavy "architectural" slates from the New York-Vermont area are sold widely for ornamental roofs. When used on large buildings with proper color blending and gradation in size they produce effects rarely equaled by any other roofing material.

Pennsylvania

Slates of Lehigh and Northampton Counties occur in a belt 2 to 4 miles wide on the south side of Blue Mountain extending from Delaware Water Gap southwest to a point 4 miles west of Lehigh Gap - about 32 miles. Quarries centered near Bangor, Pen Argyl, Windgap, and Slatington constitute the most productive slate area in the United States. The Sussex County, N. J., area has produced a small quantity of slate.

Slate occurs in the Martinsburg formation of Ordovician age. It overlies the Jacksonburg limestone, and to the northwest it dips beneath the Silurian conglomerate and sandstone of Blue Mountain. The slate belt is 1,600 to 6,000 feet wide,

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but only a few hundred feet are of commercial quality. The slates are of two types. The lower hard-vein belt occurs farthest south, passing through Belfast and Chapman quarries. Above it are beds of sandstone and higher still is the soft-vein slate belt, which extends from East Bangor through Bangor, Pen Argyl, Windgap, Danielsville, and Slatington to Slatedale.

The original bedding of the rock is marked by dark bands known as ribbons, which have been already described. The ribbon-free "big beds" are particularly prized. The soft-vein slate is used for roofing and also for the full range of mill-stock products. This area produces a large percentage of all the mill-stock products made on the American Continent. Almost all of the slate blackboards marketed come from this belt. School slates are produced chiefly in the Slatington area. The hard-vein slate is used almost exclusively for roofing and flagging.

Pennsylvania-Maryland

The slate of the Peach Bottom district is bordered by schist. It is regarded as of pre-Cambrian age and overlies older gneisses and serpentine. The slate occurs in 3 parallel belts 75 to 120 feet thick. Slaty cleavage is vertical or dips at a steep angle. Many years ago an important roofing-slate industry flourished near Delta, Pa. The dark, bluish-gray slate with a lustrous cleavage surface had a high reputation, but there has been no recent production. Granules and flour are the only slate products now made in this region.

Virginia

The best commercial slates of Virginia occur near Arvonia, Buckingham County, in a belt 200 to 250 feet wide and about 1 mile long. The rock has been identified as of Ordovician age. The bedding dips at steep angles of 80° to 85°, and the slaty cleavage parallels the bedding. The slate is dark gray or slightly greenish with a lustrous surface. It is too hard for use in mill-stock products. Some flagging is produced, but the main product is roofing slate. Several quarries have been operated in the area for many years.

Other Localities

A small output of slate products has been recorded during recent years in Montgomery County, Ark.; Eldorado County, Calif.; Polk and Barton Counties, Ga., and Baraga County, Mich.

Foreign Slate Deposits

In Canada slate has been quarried chiefly in Richmond County, Quebec. Some slate has been produced in Nova Scotia, British Columbia, and Newfoundland.

The most important slate-producing areas of the British Isles are those of Carnarvonshire and Merionethshire, Wales. The Welsh quarries are probably the most productive in the world. Slates are produced also in Cornwall, England; Argyle, Perth and Dumbarton, Scotland; and in Tipperary and Cork Counties, Ireland.

The Ardennes and Angers districts of France are important slate-producing centers. Slate is quarried also in Germany, Norway, Portugal, Italy, India, New Zealand, and Tasmania.

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MINING METHODS

Slate is usually obtained from open quarries. In Pennsylvania where the beds are nearly vertical and the slaty cleavage is 5° to 15° from horizontal, the quarries are deep and relatively narrow. A maximum depth of 700 feet has been attained, and depths up to 450 feet are not uncommon. Open bed planes known as loose ribbons commonly make quarry walls. In the absence of loose ribbons quarry walls are maintained as far as possible parallel with, and at right angles to major joints. In the New York-Vermont area where slaty cleavage dips at angles of 40° to 50°, quarries are wider and shallower. In Virginia where the slaty cleavage is almost vertical the quarries are deep and wide. In Maine the major commercial slate bed is narrow and nearly vertical. Here underground shaft mining is followed.

Primary cuts in the Pennsylvania quarries were made originally with channeling machines, which travel back and forth on a track and cut a channel with reciprocating chisel-like bars. In 1926 the Bureau of Mines assisted the industry in introducing the wire saw, which consists essentially of a wire cable running as a belt. When fed with a slurry of sand and water, and held by tension against the rock, it cuts by abrasion. This equipment conserved power and labor, lowered cost, and reduced the proportion of waste to such an extent that it soon replaced all channeling machines in the Pennsylvania slate region, but it has not been adopted in other slate-quarrying centers. In the New York-Vermont area and in Buckingham County, Va., primary breaks are made with small charges of explosives in drill holes, advantage being taken wherever possible of open joints and bed seams. In the underground operation in Maine a stoping system is used.

Experiments are being made in the use of diamond circular saws for making primary cuts in quarries, but no definite results are yet available.

MILLING METHODS

Roofing-Slate Manufacture

At quarries where roofing slate is made, the quarry blocks are subdivided by drilling and wedging parallel to the slaty cleavage and rift of the rock. Rift is a second direction of splitting less pronounced than slaty cleavage and usually at right angles to it. In the third direction at right angles to both slaty cleavage and rift there is no tendency to split. It is known as the hard way, and designated locally as the "sculp." The slabs of slate split on cleavage and rift to the desired dimensions are usually broken by sledging in the sculp direction, but sometimes they are cut to length with circular saws. These operations are known as block making.

The splitters take the blocks that have been reduced to the thickness of eight slates, and split them into roofing shingles with a thin chisel and mallet, always splitting in the center of each block and subdivision thereof. The trimmer takes the shingle from the splitter and trims it to the largest commercial size obtainable. A common trimming machine has a straight blade operating like a paper cutter.

Mill-Stock Manufacture

Blackboards, electrical panels, table tops, sinks, and all types of structural slate products, such as steps, baseboard, and window sills, are made in mills usually equipped with overhead traveling cranes of about 5-ton carrying capacity. Quarry blocks brought to the mill are first measured and marked according to the

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sizes required for the uses for which they are best adapted. They are then placed on saw beds and cut to size. Circular saws equipped with inserted carbide-tipped teeth are widely used. The saw bed on which the block of slate rests is propelled back and forth by a rack and pinion. It carries the block of slate against the saw, which rotates on fixed bearings. Saws range from 24 to 48 inches in diameter, and make cuts about 3/8-inch wide. They rotate at a rate of 6 or 7 revolutions a minute. The rate of travel of the bed depends upon the thickness and hardness of the block. It ranges from 3 to 9 inches a minute for average blocks.

The following treatment depends upon the nature of the product. Blackboards are made of true-splitting slate taken from big beds. They are split on the natural cleavage to a thickness of 3/8-inch, and the surface is generally so smooth and true that it requires only a final polish. Blocks for structural uses are split to approximate thickness plus enough material to permit finishing to a true surface on both sides. The slabs are first worked to a smooth surface on a planer. The planer bed travels back and forth in the same manner as the saw bed. The tool consists of a heavy blade set horizontally and adjustable laterally and vertically. When planed to a smooth surface the slab is turned over and the other side planed almost to the desired thickness, but allowance must be made for slight reduction in thickness during later processes of rubbing and honing.

If a smoother surface is desired the slabs are placed on a rubbing bed, which consists of a cast-iron disk 12 or 14 feet in diameter. The disk rotates on a vertical shaft, and the slabs of slate rest on the surface. Sand, carried with a stream of water, serves as abrasive. Both flat surfaces and edges are ground, not only to smoothness but to true dimensions.

Certain products, such as blackboards, billiard table tops, and electrical panels, require a smoother surface than can be obtained on a rubbing bed. A fine polish, or hone finish, is obtained using a rotating buffer head furnished with fine-grained carborundum blocks or other abrasive. Multiple-head polishing machines also are used.

Carborundum wheels are used widely for sawing slabs of slate to the desired widths for window sills or other products. According to some operators diamond saws offer definite advantages in greater speed and lower cost. An 18-inch diamond saw will cut a 1-1/4-inch slab of soft-vein Pennsylvania slate at an average rate of 5 feet a minute. Water jets are required to prevent overheating.

Several special slate products are now made in the Pennsylvania mills. Slate is finding wider use for chemical laboratory equipment such as sinks, table tops, and fume hoods. It is well suited for such use because of its high resistance to chemical action, its low absorption (0.15 to 0.19 percent), its low coefficient of expansion (0.000005 to 0.00001 per degree C.), and its high compressive strength (10,000 to 16,000 pounds per square inch).

Special products known as mapping tables require unusual precision in manufacture. They consist of slate slabs 2-1/2 inches thick, 3 to 4 feet wide and 5 to 7 feet long. They are used as bases for precision-instrument drafting or mapping. The surface must be so flat and true that variation tolerances are limited to two one-thousandths of an inch. The surfaces are brought down to customary uniformity on rubbing beds, and the slabs are then dried for 60 days at 75° to 90° F. to remove all quarry sap. After drying the surface is brought to a precise plane with abrasive paper.

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A new structural slate product developed in the New York-Vermont area is house veneer. Small rectangular units are used as facing on residences and other buildings in the same way that limestone, sandstone, and granite are employed.

As a step toward promoting greater efficiency in mill operations, Pennsylvania State University made time studies of unit processes (11).2/

Flooring and Flagging

Flagging and related products, which are attaining increasing importance, consist of slate slabs suitable for paving porches, patios, terraces, verandas, and walkways and making stepping stones. Flooring slabs are commonly sawed into squares and rectangles ranging in dimensions from 5-3/4 to 11-3/4 inches and 1/4 to 3/8-inch thick. They may be arranged in ornamental patterns, and various color designs may be made by combining slates from different localities. They are set on a concrete base with 1/4-inch cement joints between them. For outdoor use thick slabs may be employed, and irregular outlines may be preferred to formal rectangles and squares.

The most recent method of marketing slate for flooring terraces, verandas, etc. is to sell slabs in packaged form. One package consisting of 24 slabs in 7 sizes will cover an area 2-1/2 by 5 feet. Slate from several packages may be combined in ornamental patterns covering areas of various dimensions.

THE PROBLEM OF WASTE

From 70 to over 90 percent of the gross production of slate quarries is waste material. Such waste consists in part of inferior beds that must be quarried because of their close association with the commercial beds. Other sources of waste are blocks containing knots, lenses, and other imperfections; trimmings from roofing-slate sheds; and mill waste consisting of irregular ends of blocks and saw and planer cuttings. Waste is inevitable, but its reduction to a minimum is an ever-present problem. The wire saw marked an important step in this direction in Pennsylvania as it reduced quarry waste as much as 50 percent in some instances. An extension of the use of this equipment in other slate regions might result in substantial reduction in waste. Where explosives are used to separate masses of slate the waste is generally exceptionally high.

Means of utilizing waste slate have been explored to some extent. It has been found that pulverized slate is a useful filler in road asphalt mixtures, roofing mastic, linoleum and oil cloth, paint, and various other products, but only small quantities have been so used up to the present time. Slate roofing granules are made in large quantities, but only a fraction of them is derived from waste at quarries producing roofing and mill stock.

According to studies conducted at Pennsylvania State University (13) waste slate from the Pen Argyl district was found to have qualities that fitted it for several industrial uses. Both laboratory and commercial-scale plant tests indicated that slate had adequate bloating properties for making lightweight aggregate but that there is a narrow temperature range between the bloating point and the point at which melting begins with consequent sticking or agglomeration. Thus, a close temperature control is needed. Lightweight aggregate of good commercial quality was made.

2/ Underlined numbers in parentheses refer to items in the Bibliography at the end of the report.

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Laboratory tests indicated also that waste slate and steel-mill slag mixed in equal proportions made a satisfactory raw material for mineral-wool manufacture. Addition of magnesian limestone in place of slag may also give a satisfactory product.

Another potential use is for making slate-lime brick. Slate, ground to a powder, was mixed with 10 percent of lime, pressed into bricks, and cured for 7 hours at 150 pounds steam pressure. It gave a product comparing favorably with sand-lime brick in strength and other properties.

Recently abandoned slate quarries in Pennsylvania are being used for oil storage.

MARKETING

From the discussion of slate uses it is evident that the chief consuming industries are the building and maintenance trades and manufacturers of electrical equipment. As building construction is a nation-wide industry, the chief centers of slate consumption are fixed largely by freight rates, but the distances reached are modified to some extent by the effectiveness of selling agencies. Roofing slate is widely used on buildings east of the Mississippi River, but, because of high freight rates, the demand west of the Mississippi is limited to the more permanent types of structures. For the same reason little slate is used south of the Carolinas except for New Orleans where slate is favored for roofs that are designed to conserve supplies of clean rainwater. Structural slate is less affected by freight and thus has a somewhat wider market range than roofing slate.

The centers of electrical slate consumption are the large eastern and middle western industrial cities, such as New York, Boston, Philadelphia, Schenectady, Pittsburgh, Chicago, and St. Louis. The market for blackboards is general throughout the United States and Canada.

The chief marketing points for slate are Pen Argyl, Bangor, Slatington, Easton, and Philadelphia, Pa.; New York, N. Y.; Monson and Portland, Maine; Boston, Mass.; Granville, N. Y.; Poultney, Fair Haven, and Hydeville, Vt.; and Richmond, Va.

Roofing slates are graded differently in different localities. In the Pen Argyl-Bangor district of Pennsylvania they are graded as No. 1 clear, No. 2 clear, No. 1 ribbon where the ribbon is not exposed, and No. 2 ribbon where it is exposed. At Slatington, Pa., and in Vermont they are graded as No. 1, No. 2, and intermediate. The Virginia grades are No. 1 and No. 2. No. 1 may be sold in two thicknesses, 3/16 and 1/4 inch. In Vermont and Pennsylvania heavy, rough, slates are classed as architectural grades. Similar grades known as rustic or colonial rustic are marketed in Virginia. Structural slate is graded as ribbon or clear in Pennsylvania and according to color in Vermont. Electrical slate must be free of all ribbons.

Roofing slate is sold by the square (enough slate to cover 100 square feet of roof when placed with a standard 3-inch head lap). Most mill-stock products are sold by the square foot, baseboard by the running foot, and school slates by the dozen.

Commodity rail freight rates for roofing slate are available from the New York-Vermont slate district to points in the Middle West, and from the Pennsylvania roofing-slate area north and east through New England to Quebec. No commodity rates are in effect for the Buckingham County, Va., slate district, but a relatively low class rate is available. Haulage up to 200 or 250 miles is generally by truck.

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Roofing slate is sold directly to roofers, building-supply dealers, building contractors, or through jobbers or brokers. Structural slate is sold to builders and contractors. Careful classification of products by producers is an important element in successful marketing.

SPECIFICATIONS

The standard Federal specification for roofing slate is designated "Slate; Roofing," SS-S-451 dated July 26, 1932. Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at 5 cents each. Much detail on methods of placing slate on the roof, and on supplementary materials used such as nails and flashings, is given on pages 48 to 66 of a book entitled "Slate Roofs" obtainable for $1.50 from the National Slate Association, 455 West 23d Street, New York, N. Y.

Supplementary instructions on the use of standard specifications in connection with Government construction are contained in an eight-page pamphlet entitled "Slate Roofing" dated February 1950, obtainable from Public Buildings Services, General Services Administration, Washington 25, D. C. Specifications for interior structural slate are covered in an 11-page pamphlet entitled "Interior Marble, Soapstone, Slate, Etc.," dated November 1953, obtainable from the same source.

The larger manufacturers of mill-stock products have prepared specifications for blackboards, stair treads, laboratory equipment, and various other products.

SELECTED BIBLIOGRAPHY

1. BEHRE, C. H. Slate in Pennsylvania. Pennsylvania Geol. Survey Bull. M-16, 1933, 400 pp.
2. BOWLES, OLIVER. The Technology of Slate. Bureau of Mines Bull. 218, 1922, 132 pp.
3. _____. The Wire Saw in Slate Quarrying. Bureau of Mines Tech. Paper 469, 1930, 31 pp.
4. _____. The Stone Industries. McGraw-Hill Book Co., New York, 2d ed., 1939, pp. 229-289.
5. BOWLES, OLIVER, and DE VITRY, P. The Single-Strand Wire Saw. Trans. AIME, vol. 148, 1942, pp. 231-235.
6. CONLEY, J. E. Waste Slate as a Raw-Materials Source of Lightweight Aggregate. Trans. AIME, vol. 148, 1942, pp. 161-166.
7. CONLEY, J. E., WILSON, HEWITT, and KLINEFELTER, T. A. Production of Lightweight Concrete Aggregates From Clays, Shales, Slates, and Other Materials. Bureau of Mines Rept. of Investigations 4401, 1948, 121 pp.
8. DALE, T. N. Slate in the United States. Geol. Survey Bull. 586, 1914, 220 pp.
9. HARVEY, D., and KEYES, J. J. Electrical Slate. Proc., ASTM, vol. 23, Pt. II, 1923, pp. 535-544.
10. LARRABEE, D. M. The Colored Slates of Vermont and New York. Eng. Min. Jour., vol. 140, No. 12, December 1939, pp. 47-53; vol. 141, No. 1, January 1940, pp. 48-52.
11. MULLEN, W. F. A Production Analysis of the Pennsylvania Slate Industry. Pennsylvania State College, State College, Pa., 1951, 186 pp.
12. NATIONAL SLATE ASSOCIATION. Slate Roofs. New York, 3d ed., 1953, 84 pp.
13. PENNSYLVANIA STATE COLLEGE. Properties and New Uses of Pennsylvania Slate. Mineral Industries Experiment Station, Bull. 47, 1947, 168 pp.

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